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LanternPredator

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Abstract

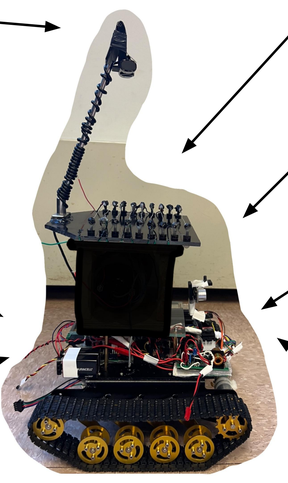
Lanternflies are an invasive pest species that can cause significant economic damage to agriculture by affecting plants and crops and disrupting the balance of natural ecosystems. These insects have a fast reproduction cycle, can withstand high-temperature variations, and have no natural predators in the US, making it very difficult to control their spread. Motivated by this environmental issue, we designed the LanternPredator, an autonomous pest control robot to help control the population growth of lanternflies. The proposed solution integrates machine learning algorithms for detecting the right insect species, an acoustic stimulus to attract the insects to a zap trap, and sonar for autonomous navigation.

Problem Formulation & Challenges

The main design challenge is to develop an integrated real-time robotic solution to patrol green spaces and lure lanternflies into a zap trap. The design challenges are listed as follows:

- How to attract lanternflies to the robot?
- How to distinguish between lantern flies and other insects?
- How to effectively get rid of lanternflies?

Proposed Robotic Solution



Camera for detecting and identifying the correct bug

Large powerful ignition coil used for activating the Zap Trap

Arduino board taking input from Sonar and sending output to H-Bridge

Acoustic bait connected to a powerful speaker

Metal chassis with wheels and tracks for navigation on uneven surfaces

Electric insects trap of 20kV

Thick layers of insulation from high voltage to the rest of robot

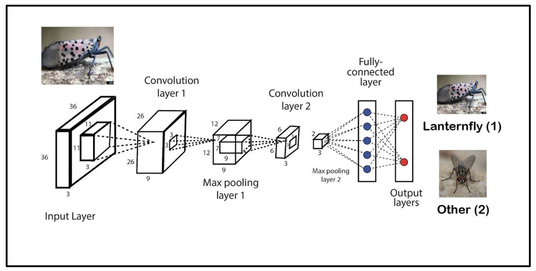
Jetson Nano taking input from top camera and sending output to Zap Trap

Sonar sensor for autonomous navigation

Powerful DC motors for navigating rough terrain

2-12v Batteries on bottom supplying power to circuitry and Zap Trap

Main Results

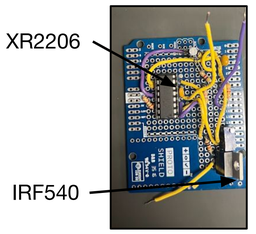


Machine Learning Lanternfly Recognition Program:

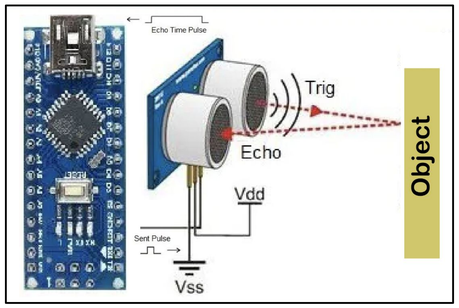
- Lanternfly recognition and identification: System recognizes lanternflies in a live feed by analyzing their wings, arms, and legs.
- Convolutional neural network: 3-layer neural network with 4800 training images achieves 93% accuracy in identifying lanternflies [1].
- Zap trap activation: Detected lanternflies trigger a 3.3v signal to activate the zap trap.

Lanternfly Bait:

- Bait selection: Based on [2], a 60 Hz sine wave at 55 dB was found to attract lanternflies effectively.
- Built a circuit to produce the pure sine wave required. Image of circuit provided to the right.
- Additional research showed that the lanternfly is also attracted to a plant called “Milkweed” which has been attached to the vehicle.



55.4 db output of Bait

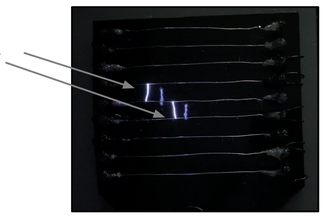


Robot Control:

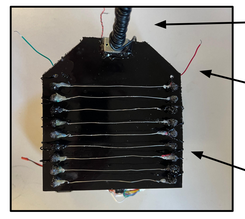
- Motor control: The robot has two DC motors controlled by an Arduino via an H-bridge.
- Encoder feedback: Each motor has two encoders to track its position and direction using complex numbers and phasors.
- Circular patrolling: The robot patrols a circular area with a designated radius. Once the maximum patrol radius is reached a new turn angle direction is randomly selected.
- Obstacle detection: The robot has a sonar sensor to detect obstacles and calculate a path to avoid them.

Zap Trap:

- Optocoupler digital reader
- NE555 timer generating AC input
- Pulse transformer
- 150 kV peak (open circuit test)



Spark of Zap Trap in action during testing



Zap trap from above

Future Work

- Solar panel enclosing exterior design for continual charging
- Zap trap that it around the entirety of the robot for a more effective surface area
- Develop a mobile application to monitor and control the robot

References

- [1] Pahinkar, Ajinkya. “Implementing CNN in PYTORCH with Custom Dataset and Transfer Learning.” *Medium*, Analytics Vidhya, 25 Aug. 2020
- [2] Rohde, Barukh.et.al. “Evidence of Receptivity to Vibroacoustic Stimuli in the Spotted Lanternfly Lycorma Delicatula (*Hemiptera: Fulgoridae*).” Journal of Economic Entomology, Issue 6, pp 2116-2120, 2022